METHOD TO MEASURE THE LENGTH OF UNGINNED COTTON FIBERS WITH A SERVO FIBROGRAPH

Production Research Report No. 162

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Mississippi Agricultural and Forestry Experiment Station

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Washington, D.C. Issued February 1976

METHOD TO MEASURE THE LENGTH OF UNGINNED COTTON FIBERS WITH A SERVO FIBROGRAPH

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ABSTRACT

A method of measuring the length of unginned cotton fibers with a servo fibrograph was developed. Fully loaded combs (14 seeds) gave the most precise results. The seeds were set into the comb in front of the teeth, and the fibers were parallelized by brushing for 30 seconds with an electric carding fiber blender. The fibrograph pen was repositioned 0.28 inch to compensate for the seeds being on the front side of the combs. A laboratory test using three cotton types and two technicians gave an average standard deviation of 0.034 inch for upper-half mean length determinations. This means that, to detect a difference of 0.03 inch between two treatments, a minimum of 21 fibrograms would be required at odds of 4 to 1. The method is more rapid than other methods of determining the length of fibers of unginned cotton. Further work would be necessary to adapt the method to the digital fibrograph.

INTRODUCTION

Length is an important characteristic of cotton fibers. It affects yarn strength and other fabric properties and is one of the principal factors in setting price when cotton is bought and sold.

Fiber length is largely determined by the cotton plant's genetic constitution and its growth environment. Harvesting practices generally do not affect fiber length, but ginning processes can affect it significantly. It is well known that the fiber moisture content during fiber-seed separation and the number of times the fibers are stressed influence the amount of breakage during ginning. If an excessive number of fibers are broken, their mean length and length uniformity are reduced and their economic value diminished — sometimes severely.

All conventional techniques for determining fiber length are limited to ginned lint; there are no practical, commercially available instruments for determining the length of fibers while they are on the cottonseed. Consequently, fiber length measurements that may be made to study the effect of seed-cotton drying and cleaning treatments on fiber length necessarily have the effects of the gin stand (fiber-seed separation) or hand ginning superimposed on them. A rapid and accurate instrument for determining the length of unginned cotton fibers would be a useful tool for cotton ginning research and in cotton breeding programs. This report describes development of a method to measure the length of unginned cotton fibers with a servo fibrograph. Further work would be necessary to adapt the method to the digital fibrograph.

[1]Retired.

PAST WORK

Many investigators have developed methods for determining the length of cotton fibers. Webb developed a duplex sorter that is still used for sorting ginned lint into ⅛-inch fiber-length groups (*10*).[2] Ahmad and Nanjundayya described a faster method of determining the average length of ginned cotton (*1*). McNamara and Stutts developed a sorter useful for removing and assaying the fibers from one seed at a time (*6*), and Pressley invented a device for manually removing fibers from 10 seeds at a time for sorting into length groups (*7*). All of these devices require either that ginned cotton be used or that fibers be removed by the instrument for manual measurement of the length groups.

Hertel and Zervigon invented an electro-optical device called a fibrograph for analyzing the length of cotton fibers on a single seed (*3*). This instrument was semiautomatic and drew a curve from which certain fiber length properties could be derived. It has since been developed into a sophisticated instrument for rapidly determining length properties of ginned lint (*2*).

Johnson also used a photoelectric cell system to determine mean length and modal length of fibers still on the seed (*4*). Measurements related to fiber length were made by recording the electric current flowing through the photoelectric cell as the fibers were passed over a slot that allowed light to shine through them. This apparatus was improved and enlarged to accommodate eight seeds at a time (*5*), but use of the device required manual movement of the fibers and visual observation of a microammeter to collect data.

PRELIMINARY EXPERIMENTS

An early model of a lint-cotton fibrograph that had been converted from manual to servo operation (*8*, *9*) was used for the study.

One of the first problems encountered was how to present the fibers to the scanner. In the first trial, 20 cottonseeds were butterflied and set into the combs with the seeds behind the combs. The seeds were then removed by shearing with a razor blade, and the fibrograms were made in the normal manner. Shearing was necessary to remove the seeds so that the combs would lie flat against their holders. Although some fibers were removed during butterflying, their loss was judged insignificant.

Another method of preparation was to crush the seeds so that the combs would lie flat. During these trials, the number of seeds in the combs was varied, and five varieties of cotton were tested; there was considerable variation in test results (table 1).

TABLE 1.—*Effect of specimen and comb preparation on upper-half mean length of five varieties of seed-cotton fibers*[1]

Variety code	Upper-half mean length (inches)				
	Sheared fibers parallelized by [2]—			Number of crushed seeds in combs [3]	
	Hand	Blender	Air	10	14
1	1.04	0.98	0.93	1.01	1.12
2	1.08	1.02	.98	1.02	1.06
3	1.15	1.06	1.10	1.08	1.09
4	1.16	.98	.95	1.00	1.00
5	1.27	1.23	1.20	1.20	1.26
Average	1.14	1.05	1.03	1.06	1.11

[1]Each value is the average of 2 measurements.

[2]Cottonseeds set behind combs and removed after parellelizing and shearing with razor blade.

[3]Parallelized by compressed air.

In the next trial whole seeds were used in the combs. The fibers on each seed were divided by hand, set into the combs, and straightened by a third comb. The combs were then clamped into position below the regular combholders. Relocating the combs required resetting the fibrogram tracing pen. A number of fibrograms were made. Comparison of these data with data from the fiber arrays showed considerable discrepancy between fibrograph seed-cotton mean length and Suter-Webb array mean length (table 2).[3]

[2]Italic numbers in parentheses refer to items in "Literature Cited," page 6.

[3]The terms "mean length" and "upper-half mean length" do not, strictly speaking, apply to unginned lint since the conditions of measurement do not satisfy fibrograph theory. These terms are used because the measurements were obtained by the same graphical procedures used to determine the upper-half mean and mean length of ginned lint on the fibrograph.

TABLE 2.—*Fibrograph mean length of unginned fibers and Suter-Webb array mean length of the same fibers removed from their seeds by hand ginning*

Variety code	Mean length (inches)	
	Fibrograph (unginned)	S-W array (hand ginned)
1	0.86	1.02
2	1.05	.96
3	.92	1.03
4	.82	.96
5	1.04	1.10
Average	.94	1.01

By this time, it appeared that determining the true length of the fibers was not as important as establishing a technique for making fiber length measurements — one that was sufficiently precise to detect reductions in original fiber length caused by breakage by the gin overhead equipment. Thus, the work turned in the direction of finding an acceptable technique, with reasonable precision, for measuring the length of unginned cotton fibers.

METHOD DEVELOPMENT

Based on observations and experience gained during the preceding experiments, the following method of loading and preparing the combs was selected. The seed units were set on the combs (7-12 per comb) with the seeds in front of the teeth and with about half the fibers extending through the teeth toward the comb handle. Manual straightening of the fibers was replaced by a parallelizing process, using a rotating carding cylinder fiber blender. A metal holding bar pressed the rearward projecting fibers and held the seeds on the combs while the forward fibers were worked. It was necessary to raise the pen carriage 0.28 inch with the seeds on the fibrograph combs so that the length measurements would not include the seeds at the front of the combs. These tests showed that, as the number of seed units used on each comb was increased, the fibrograms were more uniform and therefore more satisfactory for length analysis. In an experiment in which 10 fibrograms were made from the same pair of 12-seed combs, the range for upper-half mean length (UHML) was only 0.03 inch, and the standard deviation was only 0.011 inch with the UHML value averaging 1.40 inches (table 3). Measurements of mean length (ML) gave values of 1.25, 0.07, and 0.025 inches for the average, range, and standard deviation, respectively.

The effect of the amount of combing on the precision of the measurements was evaluated with 10-seed units per comb and combing for 0, 15, 30, 45, and 60 seconds. The experiment, replicated 10 times, showed that 30 seconds of combing gave the best combination of maximum measured length and low variability (table 4).

The effect of the number of seeds on the combs was reexamined after the optimum combing time had been established. Comb loadings of 10, 12, and 14 seeds per comb were used; the tests were replicated 10 times. Although differences in UHML and ML values related to the number of seeds on each comb were not statistically significant, there was a noticeable trend for the value of the length parameters to increase as comb loading increased (table 5). The standard deviation of length values for each seed loading decreased as the number of seeds per comb increased; the change was more pronounced for UHML than

TABLE 3.—*Ten measurements of upper-half mean length and mean length of unginned cotton fibers made by one operator on the same set of loaded combs*[1]

Measurement	Upper-half mean length (inches)	Mean length (inches)
1	1.38	1.25
2	1.39	1.26
3	1.39	1.26
4	1.39	1.21
5	1.39	1.21
6	1.39	1.25
7	1.40	1.26
8	1.41	1.27
9	1.41	1.26
10	1.41	1.28
Average	1.396	1.251
Standard deviation	.011	.023
Range	.03	.07
Coefficient of variation (%)	.79	1.84

[1]12 seeds per comb. Parallelized using fiber blender.

for ML data but was obvious in both sets of measurements. It was concluded that all future work should be done with fully loaded combs (14 seeds per comb).

The final experiment in this investigation was to evaluate the effects of operators and cotton types on the quality of the measurements. For this work, samples were chosen to represent short-, medium-, and long-staple cottons. Two technicians were instructed to prepare combs and make fibrograms until each had made 10 smooth fibrograms from each type of cotton; the number of fibrograms in each set varied from 16 to 24. The fibrograms were measured for UHML and ML in inches. Then, 15 fibrograms were randomly selected from each set for statistical analyses. The data are presented in tables 6 and 7.

An analysis of variance of the UHML data showed significant differences among staple-length types, but not between operators. The overall standard deviation for these data was 0.034 inch. A similar analysis of ML data showed no significant differences in the ML of the medium- and long-staple cottons by either operator. Since the cotton types had been selected by variety for differences in staple length and since the ML data failed to detect it and the UHML data did detect it, the UHML determinations were considered to be more responsive and useful in measuring the length of unginned cotton fibers by the method being developed.

To be satisfactory for detecting fiber break-

TABLE 4.—*Effect of amount of combing on upper-half mean length and mean length of unginned cotton fibers*[1]

Combing period (seconds)	Upper-half mean length[2]			Mean length[2]		
	Avg. (inches)	SD (inches)	CV (percent)	Avg. (inches)	SD (inches)	CV (percent)
0	0.96	0.036	3.75	0.87	0.035	4.02
15	1.15	.038	3.30	1.04	.035	3.37
30	1.15	.030	2.61	1.04	.026	2.50
45	1.14	.035	3.07	1.04	.034	3.27
60	1.13	.028	2.48	1.02	.031	3.04

[1]Each value is the average of 10 trials.
[2]SD, standard deviation. CV, coefficient of variation.

TABLE 5.—*Effect of 10, 12, and 14 seeds per comb on upper-half mean length and mean length of unginned cotton fibers*[1]

Replication[2]	Upper-half mean length (inches)			Mean length (inches)		
	10 seeds	12 seeds	14 seeds	10 seeds	12 seeds	14 seeds
1	1.07	1.07	1.11	0.98	0.99	1.00
2	1.10	1.11	1.14	1.02	1.00	1.02
3	1.10	1.12	1.14	1.02	1.00	1.03
4	1.11	1.13	1.14	1.03	1.03	1.03
5	1.12	1.14	1.15	1.04	1.04	1.05
6	1.12	1.15	1.16	1.04	1.04	1.06
7	1.13	1.15	1.17	1.04	1.05	1.06
8	1.16	1.16	1.17	1.07	1.05	1.08
9	1.17	1.16	1.18	1.08	1.06	1.08
10	1.22	1.20	1.20	1.10	1.10	1.10
Average[3]	1.130a	1.139a	1.156a	1.042b	1.036b	1.051b
Standard deviation	.043	.035	.025	.034	.033	.031
Coefficient of variation (%)	3.81	3.07	2.16	3.26	3.19	2.95

[1]Combs prepared by 30 seconds of combing with fiber blender.
[2]Listed in order of increasing fiber length.
[3]Averages followed by different letters are significantly different at the 0.01 confidence level.

TABLE 6.—*Effect of two operators and three cotton types on upper-half mean length of unginned cotton fibers*[1]

Fibrogram[2]	Upper-half mean length (inches)					
	Short-staple cotton		Medium-staple cotton		Long-staple cotton	
	Op. 1	Op. 2	Op. 1	Op. 2	Op. 1	Op. 2
1	1.03	0.95	1.20	1.18	1.23	1.24
2	1.06	.96	1.21	1.19	1.28	1.26
3	1.06	1.02	1.21	1.22	1.28	1.27
4	1.07	1.02	1.22	1.23	1.29	1.27
5	1.07	1.04	1.22	1.23	1.29	1.28
6	1.08	1.04	1.23	1.23	1.30	1.29
7	1.08	1.05	1.24	1.23	1.30	1.30
8	1.08	1.06	1.25	1.25	1.30	1.32
9	1.08	1.06	1.25	1.25	1.31	1.33
10	1.09	1.07	1.25	1.25	1.32	1.34
11	1.09	1.08	1.26	1.25	1.32	1.34
12	1.10	1.08	1.26	1.25	1.32	1.35
13	1.10	1.08	1.26	1.26	1.32	1.36
14	1.13	1.09	1.27	1.26	1.33	1.37
15	1.16	1.09	1.30	1.26	1.34	1.38
Average[3]	1.085a	1.046b	1.242c	1.236c	1.302d	1.313d
Standard deviation	.030	.043	.027	.024	.027	.044
Coefficient of variation (%)	2.76	4.11	2.17	1.94	2.07	3.35

[1]14 seeds per comb; combed 30 seconds on fiber blender.
[2]Selected randomly and listed in order of increasing upper-half mean length.
[3]Averages followed by different letters are significantly different at the 0.01 confidence level.

TABLE 7.—*Effect of two operators and three cotton types on mean length of unginned cotton fibers*[1]

Fibrogram[2]	Mean length (inches)					
	Short-staple cotton		Medium-staple cotton		Long-staple cotton	
	Op. 1	Op. 2	Op. 1	Op. 2	Op. 1	Op. 2
1	0.96	0.84	1.02	1.03	1.06	1.04
2	.96	.88	1.05	1.06	1.09	1.07
3	.96	.93	1.07	1.08	1.10	1.07
4	.96	.94	1.07	1.10	1.12	1.07
5	.96	.94	1.08	1.13	1.12	1.10
6	.97	.94	1.12	1.13	1.15	1.12
7	.98	.96	1.13	1.14	1.16	1.12
8	.98	.97	1.13	1.15	1.16	1.16
9	.99	.98	1.14	1.16	1.16	1.16
10	1.00	.98	1.14	1.16	1.17	1.17
11	1.01	.98	1.15	1.16	1.17	1.18
12	1.01	.98	1.15	1.17	1.18	1.18
13	1.02	.99	1.16	1.17	1.18	1.18
14	1.03	1.00	1.22	1.20	1.19	1.20
15	1.03	1.00	1.24	1.21	1.20	1.22
Average[3]	.988a	.954a	1.125b	1.137b	1.147b	1.136b
Standard deviation	.027	.045	.060	.050	.040	.056
Coefficient of variation (%)	2.73	4.72	5.33	4.40	3.49	4.93

[1]14 seeds per comb; combed 30 seconds on fiber blender.
[2]Selected randomly and listed in order of increasing mean length.
[3]Averages followed by different letters are significantly different at the 0.01 confidence level.

age before lint-seed separation by the gin stand, the test should detect a change in UHML of 0.03 inch. By substituting in the equation $n=2s^2t^2/d^2$ (where n=number of measurements, s=standard deviation, t=probability factor, and d=least consequential difference), the minimum number of measurements necessary to detect a difference of 0.03 inch between two treatments at the 0.05 confidence level at odds of 50-50 was found to be 11. When the calculation is based on 4 out of 5 chances for detecting a difference of 0.03 inch at the 0.05 confidence level, the number of measurements required per treatment is 21.

Differences much greater than 0.03 inch are not expected to occur, and differences less than 0.03 inch are considered of little importance. Consequently, 21 UHML measurements per treatment may be considered the minimum required for use of this method to determine fiber-length differences in unginned cotton.

LITERATURE CITED

(1) Ahmad, N., and Nanjundayya, C. 1936. A new method and apparatus determining the average length and fineness of cotton hairs. Indian Centennial Cotton Comm. Technol. Lab. Tech. Bull. Ser. B., No. 21, 22 pp.

(2) American Society for Testing and Materials. Standard method of test for length of cotton fibers by fibrograph measurement. ASTM Designation D 1447-72. The Society, Philadelphia.

(3) Hertel, K. L., and Zervigon, M. G. 1936. An optical method for the length analysis of cotton fibers. Text. Res. 6: 331-339.

(4) Johnson, B. 1938. A photoselectric sorter for length measurements of fibers of seed cotton. J. Agric. Res. 57 (1): 41-56.

(5) ———. 1939. Apparatus for measurements of lengths of cotton fibers. Univ. Ark. Agric. Exp. Stn. Bull. No. 381, 56 pp.

(6) McNamara, H., and Stutts, R. 1935. A device for separating different lengths of fibers from seed cotton. U.S. Dep. Agric. Circ. No. 360, 16 pp.

(7) Pressley, E. H. 1933. A new type of cotton sorter. J. Am. Soc. Agron. 25(2): 89-98.

(8) Tallant, J. D. 1952. Use of a servo system for automatic operation of the fibrograph. Text. Res. J. 22(9): 617-619.

(9) ———. 1958. Improvements in the servo conversion of manual fibrographs. Text. Res. J. 28(9): 815.

(10) Webb, R. W. 1932. Suter-Webb cotton fiber duplex sorter and the resulting method of length-variability measurements. Am. Soc. Test. Mater. Proc. 32(2): 764-771.